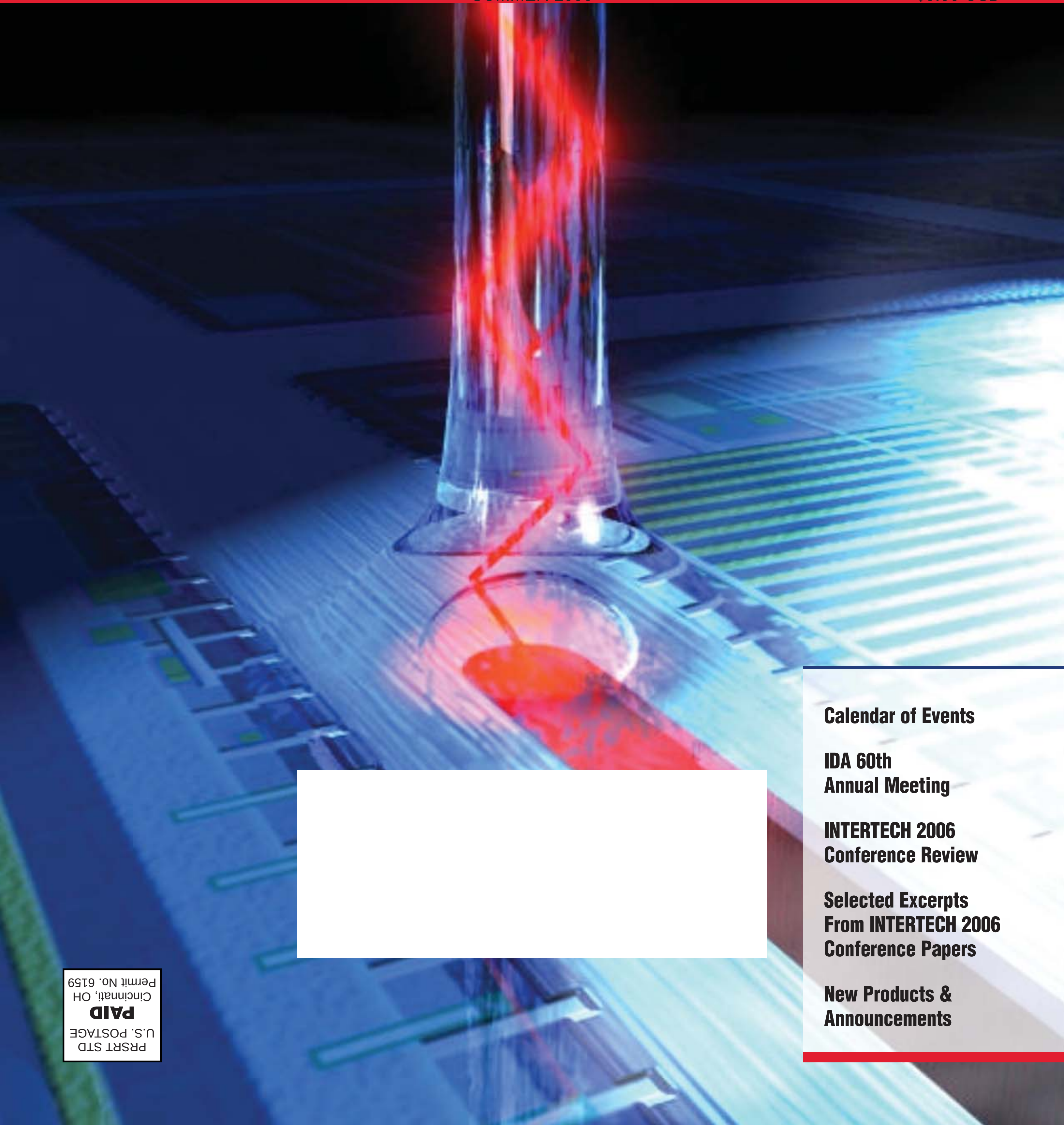
FINER POINTS

1946 60th ANNIVERSARY 2006
INDUSTRIAL DIAMOND ASSOCIATION OF AMERICA, INC.

"The ONLY magazine dedicated solely to the technology and application of superabrasives."

INTERTECH 2006 Review

SUMMER 2006
$9.00 USD



Calendar of Events

IDA 60th Annual Meeting

INTERTECH 2006 Conference Review

Selected Excerpts From INTERTECH 2006 Conference Papers

New Products & Announcements

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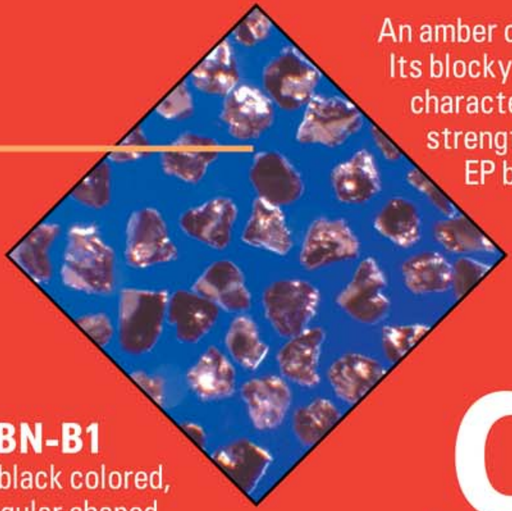

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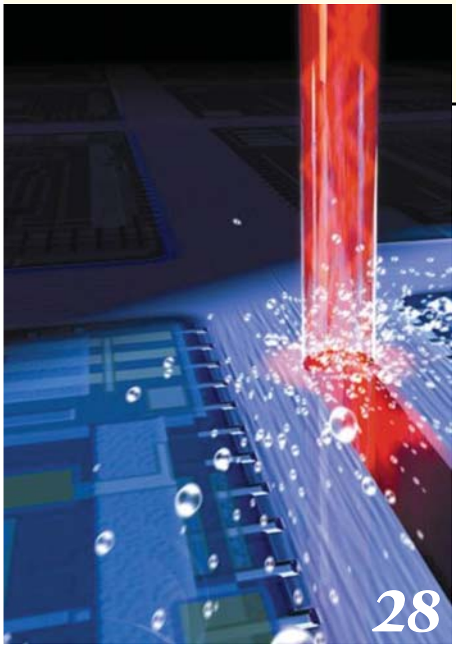

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Laser Cutting of Ultra-Hard Materials.
Photo courtesy of Synova SA,
Switzerland.

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FINER POINTS is the only publication devoted exclusively to the understanding, selection and application of diamond, cubic boron nitride and related materials. It is edited for recipients who are involved in some way with these "superabrasives", either as providers of the materials, producers of products containing the materials or users of these products (e.g., grinding wheels, dressing tools, drill bits, saw blades, sawing wires, cutting tools, polishing compounds, CVD film products, etc.).

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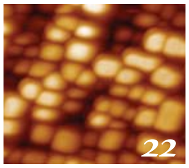

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Diamond Abrasives Corp. .... OBC
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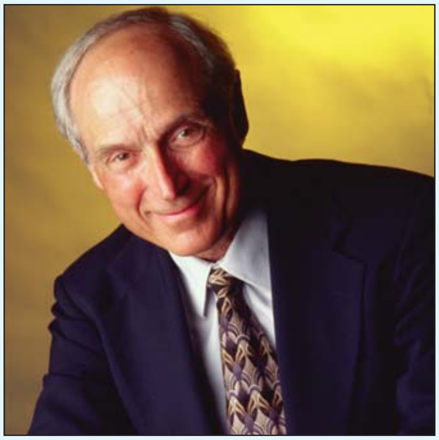
A Finer Point of View…

INTERTECH 2006 Signals Positive Direction For Industry



PRESIDENT
Robert Linares

At the most recent Industrial Diamond Association of America Annual Meeting, which just happened to be the 60th Anniversary of the IDA, I was thrilled to be inducted as the new IDA President. After serving for the past few years on the Board of Directors and as an Officer, I look forward to adding my own personal insight and efforts to continue in the long line of hard working and dedicated Presidents of the IDA over the last 60 years. I take over as we are still basking in the glow of a tremendously successful INTERTECH 2006. For those of you who were there, you know that the recent INTERTECH in Atlanta was a major success in every way. For those of you who were not there, the good news is that the next INTERTECH will be held in two years at the Contemporary Resort in Orlando, Florida USA. The success of this year's INTERTECH was a tribute to the hard work of the organizing and program committees who provided a great venue for the meeting and outstanding papers, both invited and contributed. This year, the planning committee structured the Conference a little different to take into account suggestions on what worked and what needed to be adjusted for improvement. First, we shortened the conference to make it more focused and easier for all to attend. Second, we limited the number of papers to allow for more discussion and participant interaction, this was very well received and improved the quality of the papers accepted. Parallel sessions were limited in order to afford people the opportunity to hear new ideas outside of their usual areas of interest. This "cross over technology" allowed many to hear presentations they normally would not see at "single topic" seminars. The Organizing Committee keyed on having more end-users as part of the program and INTERTECH itself has been established to have a blend of theoretical and technical content with a strong focus on real world use and end user application. We were fortunate to have a range of invited academic and industrial speakers, who gave us a glimpse of the future for diamond and cBN. Contributed talks were particularly relevant and represented mostly new information. A total of 248 people from 19 countries attended. We had 6 invited Keynote speakers and a total of 54 contributed talks selected from almost 90 submitted abstracts. This allowed for a very excellent program. We had an overall outstanding response from most of our attendees, and evaluation sheets indicated that they were very pleased with all aspects of INTERTECH 2006. The tabletop exhibits also received high marks and every company who had a table felt they made many good contacts and had meaningful conversations with attendees. All suggestions and comments from the evaluation sheets will be taken into account to make future INTERTECH conferences much stronger in meeting the needs of our global audience. Plans are well under way for INTERTECH 2008 and future venues are being evaluated as well for this continuing International event. If you have any ideas or suggestions (especially for content or future locations) please contact our INTERTECH 2008 Chairman, Terry Kane at tkane-ida@insight.rr.com or contact me and I will be happy to discuss your ideas. Watch the INTERTECH Conference website at www.intertechconference.com for updates and details.

Sincerely,

Robert Linares, President
Industrial Diamond Association of America

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Editorial

TERRY KANE, Editor

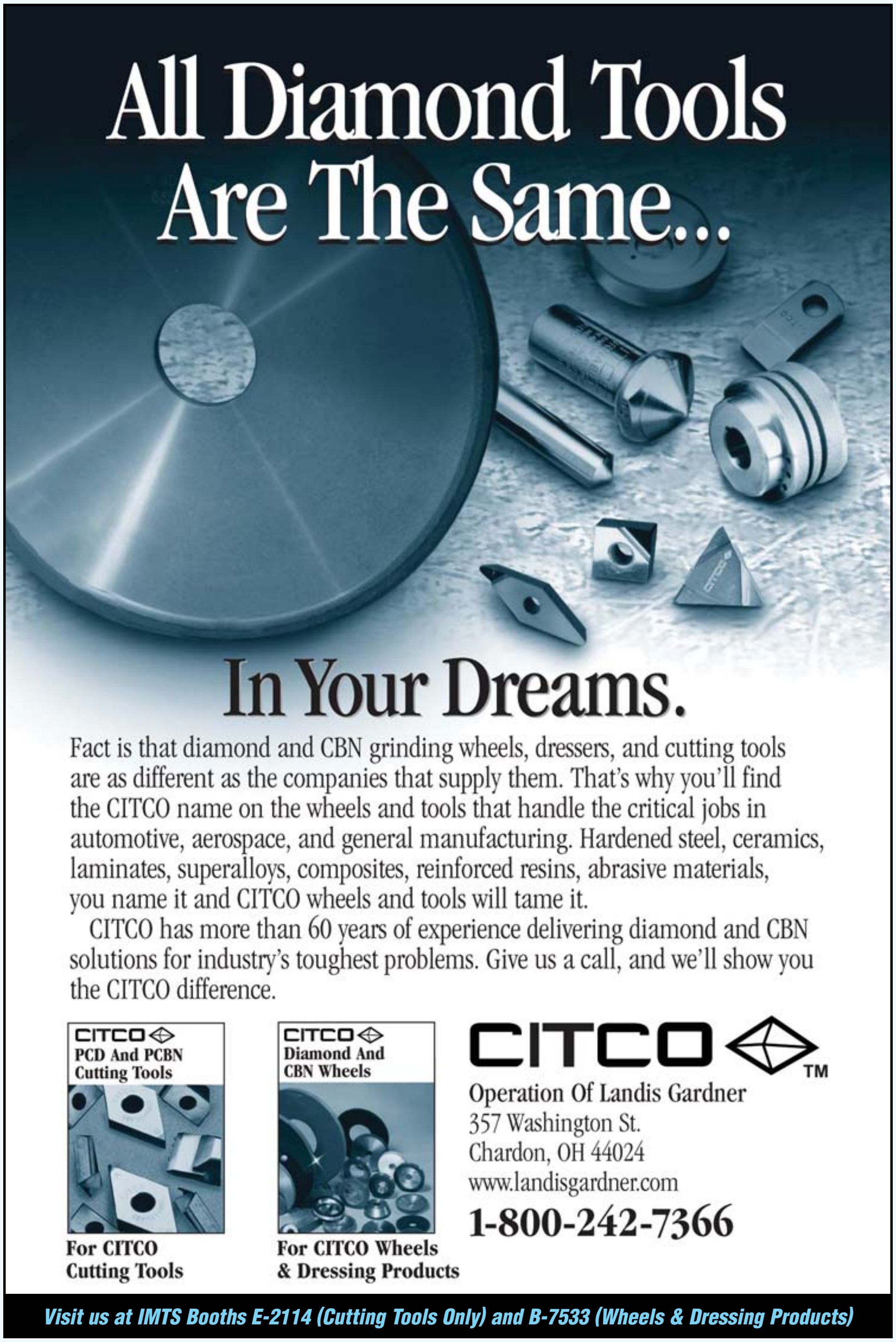
Dumping – Illegal And Unethical

All of us that do business in this industry are very concerned about price of our products and maybe even more importantly which direction those prices are heading. Outside influences can affect these prices in many ways. It goes without saying that all our costs to do business and manufacture a product, whether a superabrasive material, or a finished tool, have increased over the years, most notably due to health care and employee benefits, not to mention skyrocketing energy and raw material costs. Kimberley has added more expense in time for tracking and paperwork as well as special shipping fees. The face of the industry has also changed in terms of the number of global players. New companies, marketing techniques and the product offerings from around the world continue to impact the way we do business.

As we watch all these indicators, it has to be an even bigger aggravation (to say the least) to hear about dumping of products and materials into our industry. Dumping in its basic form is exporting a product at a lower price than a company would normally charge for that same item in its home market. Of course this is unfair competition and while the World Trade Organization (see: http://www.wto.org/english/tratop_e/adp_e/adp_e.htm) admittedly does not pass judgment on countries, it does focus on how governments react to this practice. A recent action by the Diamond Sawblade Manufacturers' Coalition, an ad hoc trade association, which includes some IDA Member companies, filed a petition with the Department of Commerce regarding dumping allegations against Diamond sawblade companies in China and Korea. The U.S. Department of Commerce found that some producers/exporters from China and Korea have sold diamond sawblades in the United States at less than fair value. As a result of these final determinations, the Department will instruct U.S. Customs and Border Protection to collect a cash deposit or bond at the rate of the final margins on imports of merchandise subject to these investigations. For complete details go to http:// trade.gov/press/press_release/2006/sawblades_051606.asp.

The U.S. International Trade Commission (ITC) is scheduled to issue its final injury determination. Should the ITC make an affirmative final determination that imports from the PRC and Korea materially injure, or threaten material injury to the domestic industry, the Department will issue antidumping duty orders and instruct U.S. Customs and Border Protection to collect cash deposits on imports of subject merchandise. If the ITC makes a negative determination, the investigations will be terminated and no orders will be issued.

Fair competition makes the market stronger, companies work harder to improve their product offerings and drives research that makes us all better. Unfair competition and practices weakens the industry through lower quality products, lack of technical support and causing widespread distrust. It behooves us all to keep constant vigilance on areas such as this in order to make sure that no illegal or unethical practices are allowed to procreate without challenge.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Fact is that diamond and CBN grinding wheels, dressers, and cutting tools are as different as the companies that supply them. That's why you'll find the CITCO name on the wheels and tools that handle the critical jobs in automotive, aerospace, and general manufacturing. Hardened steel, ceramics, laminates, superalloys, composites, reinforced resins, abrasive materials, you name it and CITCO wheels and tools will tame it.

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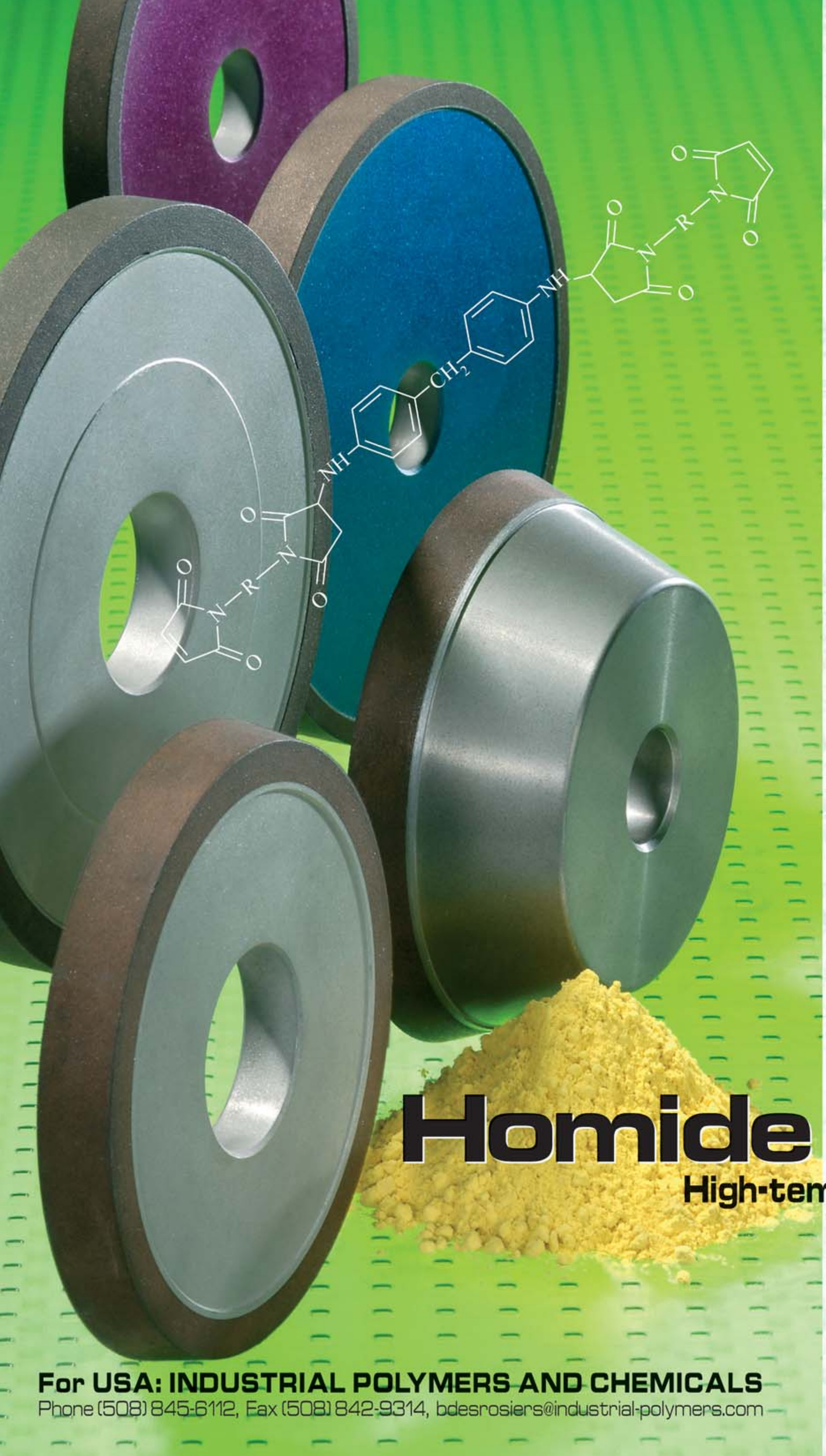

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Announcements & PRODUCTS

Csiro Manufacturing & Infrastructure Technology Has Taken X-Ray Technology To A New Level, Developing And Using High-Powered Microscopes To See Inside Objects And Capture High- Resolution Images Of Their Subsurface Structures. Using powerful X-ray microscopes and experimenting with a variety of X-ray phase-contrast imaging techniques, scientists have been able to use the penetrating power of X-rays to directly image the internal microstructures of even opaque and multi-layer objects. It is now possible to use X-rays to see inside objects such as micro-electronic components, structural materials used in aerospace, ceramics, metal foams and even minerals. An X-ray ultramicroscope can deliver submicron resolution of the internal structures of opaque and multi-layer objects down to 50nm (one thousandth the diameter of a human hair), while phase-contrast imaging with commercial X-ray microfocus sources enables improved contrast with resolution down to about a micron. *For further information visit: www.csiro.au.*

SUNNEN HELPS MEDICAL COMPONENT MANUFACTURERS MEET EXTREME BORE SIZE TOLERANCES

New honing technology from Sunnen Products Company can help medical component manufacturers obtain the extreme bore sizing accuracy and surface finish necessary for medical devices. A horizontal, single-spindle system, the KGM-5000 is designed for jobs that require ultra-accurate and consistent size control. The system is capable of holding straightness and roundness tolerances to within 0,00025 mm (0.000010") in a production environment. The honing process used with the KGM-5000 system does not generate intensive heat, thus improving bore tolerances and eliminating metallurgical heat damage to the parts—very important with medical components. The KGM is also capable of honing extremely hard or exotic materials common in the medical industry. *Simple For more information, contact Sunnen Products Company, www.sunnen.com.*

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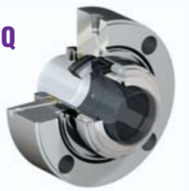
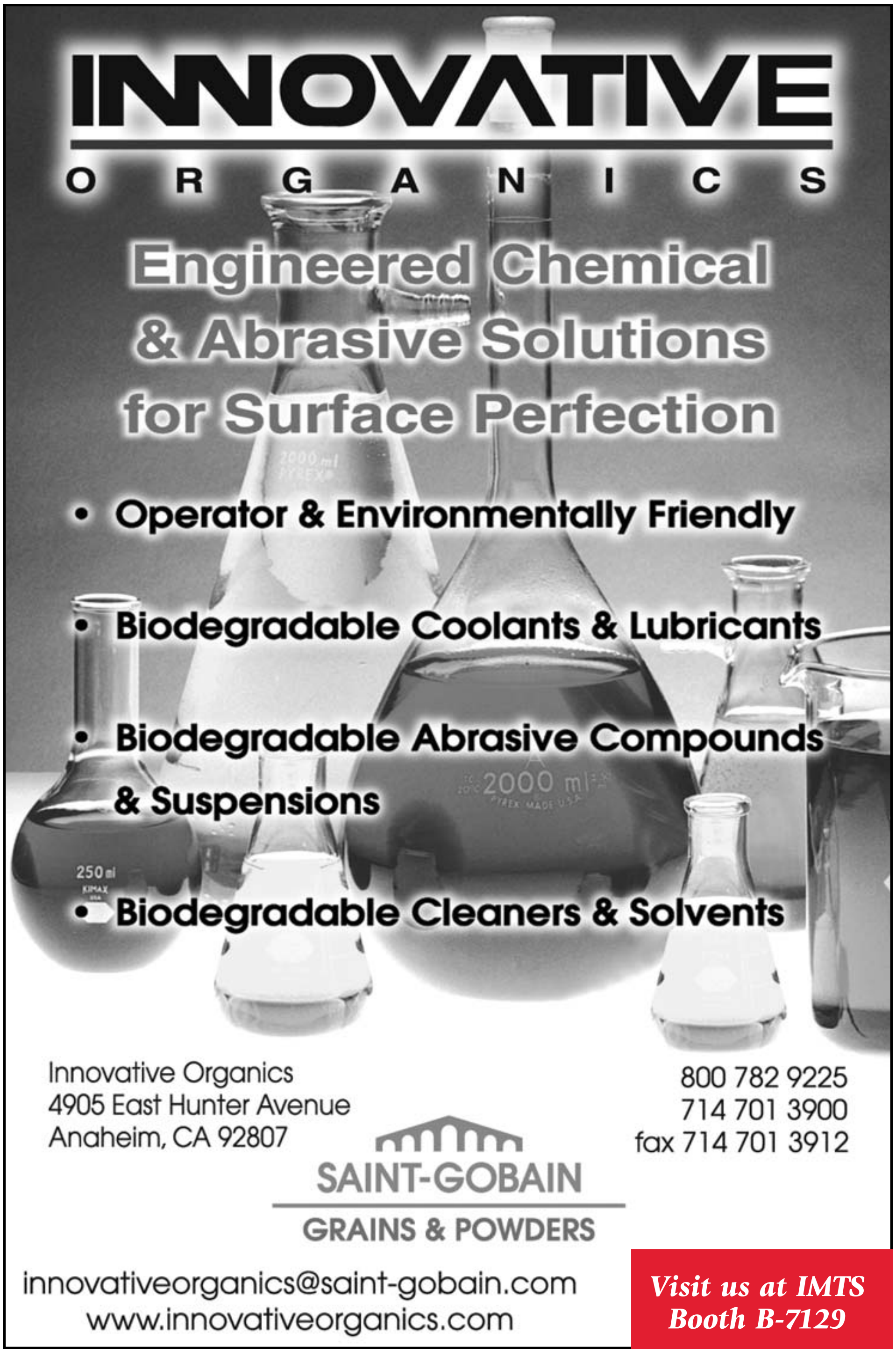
IMPROVED 3D FITTING SOFTWARE SOLVES COMPLEX MANUFACTURING PROBLEMS

Kotem Technologies, a leading developer of GD&T (Geometric Dimensioning and Tolerancing) and fitting software for precision metrology, announces a number of enhancements to its popular SmartFit® 3D best-fitting and analysis software. Taking measured part data from popular CMM, video, and laser metrology systems, SmartFit 3D troubleshoots manufacturing processes and finds the best coordinate system for machining and assembly. This uniquely capable software assesses profile tolerances on complex surfaces, provides advice on corrections by simulation, and solves misalignment and location problems so that parts can be repositioned. Airbus relies on SmartFit software (inset), by Kotem Technologies, to increase assembly speed and enhance quality during final assembly of the A380, the world's first true double-deck jetliner. *Additional product information is available online at www.ogpnet .com/ogpSofSmartFit3D.jsp*



FLOWSERVE LAUNCHES QBQ LZ MECHANICAL SEAL

Patented design creates high-reliability sealing solution for light hydrocarbon service pumps operating at low vapor pressure margin - Beyond its application for vapor pressure margins between 5.0 and 50 psi, the QBQ LZ can also be used for high-pressure pumps above 300 psi (20.7 bar) at any vapor margin. The QBQ LZ operating range includes pressures from 0 to 750 psi (0 to 51.7 bar), temperatures between -40 and 400 degrees F (-40 to 203 degrees C), speeds between 20 and 75 fps (6.1 to 23 m/s), and sizes between 1.750 and 5.125 inches (44.4 to 130 mm). *For technical information, e-mail jparker@flowserve.com*



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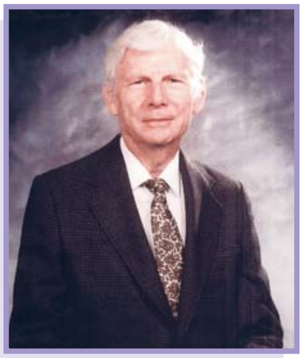
NEWS and notes

IN MEMORIAM – Dr. Bruce W. Dunnington



It is with our deepest regret to learn of the recent passing of Dr. Bruce Dunnington, founder and President of Glennel Corporation, now well known as Wendt USA-Dunnington Division. Bruce was known worldwide as an expert on diamond abrasives, dressing products, and diamond finishing processes. Early in his distinguished career he worked at DuPont as a Senior Research Supervisor for the Atomic Energy Division. Later he was involved in diamond development activities, was co-inventor of the process for synthesizing diamond and was instrumental in commercializing this valuable new product. He also held a position at Battelle Institute where he was active in the development of nuclear fuels and other advanced materials. Bruce was the driving force during the early years of Glennel and recruited many of the talented and loyal people still employed today at Wendt USA. His family, close friends, and former employees will greatly miss him.

ELEMENT SIX INDUSTRIAL SYNTHETIC DIAMOND FACTORY OPENED IN CHINA

A new industrial synthetic diamond factory has been opened in Suzhou, China, in the presence of Element Six directors and shareholders, local government officials, diplomatic representation from Ireland and South Africa and various trade organizations. The factory in Suzhou Industrial Estate (SIP) is the first Element Six manufacturing site in Asia and will produce a specialized type of synthetic diamond for internal use in the manufacturing of polycrystalline products. The total planned investment volume in Suzhou amounts to 25 Mio US$ and will gradually be expanded to add a total of around 300 Mio carats of synthetic diamond to the annual Element Six synthesis capacity. Element Six CEO Christian Hultner said, "Our factory in Suzhou employs exclusively Chinese technology in industrial diamond synthesis.” For further information: Andreas Anker, Senior Manager Group Communications, Element Six Ltd, Shannon, Co Clare, Ireland, +353-61-471655

KNORR-BREMSE HAS BEEN RANKED 1st IN THE BRAKES CATEGORY AMONGST THE ‘BEST BRANDS 2006’

This year, for the second time, the process of choosing the best brands in the truck sector took place parallel to selection of the ‘Best Commercial Vehicles’ by the ETM publishing house and testing and inspection company DEKRA. Almost 10,000 readers of the specialist journals trans aktuell, FERNFAHRER and lastauto omnibus took part in the voting - and selected Knorr-Bremse for first place. Heinz-Dieter Wigges, Chairman of the Board of Management of Knorr-Bremse Systeme für Nutzfahrzeuge GmbH, received the award at a ceremony on June 28, 2006 in Stuttgart attended by many representatives of the commercial vehicle industry. “We are delighted that this specialist public has selected Knorr- Bremse as the best brand in the brake category. This honor is a token of the confidence that decision-makers and operators have in our products. To find out more about Knorr-Bremse, visit www.Knorr-Bremse.com.

HEATED GLASS HAS A NEW NAME: THERMIQUE TECHNOLOGIES, LLC

Chicago, Illinois – A brand new wholly owned subsidiary called Thermique Technologies, LLC, will take control of all heated glass projects, products and technologies from Engineered Glass Products. Thermique Technologies will concentrate on the development, sales and marketing of Thermique™ heated glass, allowing EGP to remain focused on its core business of heat-reflective glass in kitchen appliances. Thermique™ heated glass is a proprietary technology developed by EGP to uniformly heat a pane of glass with precise control. The creation of Thermique Technologies as a separate company is designed to streamline the operations of both companies for greater efficiency and customer service. “Thermique™ glass has countless advantages over competing sources of radiant heating—including efficiency, style, convenience, simplicity and attractiveness. The range of applications for this new technology is almost limitless.” To see the latest product designs from Thermique Technologies as well as the latest developments in heated glass technology, visit www.ThermiqueTechnologies.com.

THE COMPLETE OSHA GUIDE TO FALL PROTECTION

Davenport, Iowa – To help companies protect their workers against fall-related accidents and stay compliant with the Occupational Safety and Health Administration (OSHA), safety-industry publisher MANCOMM has developed The Complete OSHA Guide to Fall Protection (Product No. 36B-001). Like many MANCOMM reference works, this 140+ page, 8-1/2" x 11" volume is enhanced with RegLogic®, a colorful, graphical approach that makes reading and understanding regulations easier than ever. “This guide will do much to help companies protect their workers from fall-related accidents,” said Benjamin Mangan, president and founder of MANCOMM. “When the Occupational Safety and Health Administration (OSHA) revealed the 10 mostviolated OSHA standards, the third most-cited standard was Fall Protection with 5,504 violations. America’s workplaces need more fall-protection education. The Complete OSHA Guide to Fall Protection, currently in production, is now available for pre-order. For more information, visit www.mancomm.com

Calendar of EVENTS

To have your event or conference listed, please send information to:

Finer Points Event Calendar
P.O. Box 29460, Columbus OH 43229
Fax 614-797-2264 or
email: tkane-ida@insight.rr.com

CMSC

July 17-21
The Coordinate Metrology System Conference
Doubletree Hotel in Orlando, Florida USA
e-mail belinda.jones@hitechmarketing.com
www.cmsc.org

The Star INTERBUILD AFRICA 2006
CONSTRUCTIVE BUILDING SOLUTIONS

July 26-29
Johannesburg, South Africa
www.interbuildafrica.co.za

SME Society of Manufacturing Engineers

August 23-24
Nanotechnology and Manufacturing Event
Pollard Technology Conference Center
Oak Ridge, Tennessee USA
www.sme.org

IWF 2006
Atlanta, GA USA

August 23-26
International Woodworking Fair
Georgia World Congress Center,
Atlanta, Georgia USA

IMTS.COM
INTERNATIONAL MANUFACTURING TECHNOLOGY SHOW

September 6-13
International Manufacturing Technology Show
McCormick Place, Chicago, IL USA
www.imts.com

SME Society of Manufacturing Engineers

September 18-20, 2007
GREAT LAKES 2007
"Exploring Manufacturing Innovations" conference and exposition
DeVos Place, Grand Rapids, MI
USAwww.sme.org

September 18-22

International Machine Tools Exhibition
Exhibition Centre
Brno, Czech Republic
www.bvv.cz

AMB 2006

September 19-23
International exhibition for metalworking
Stuttgart Trade Fair & Convention Center
Stuttgart Germany
www.messe-stuttgart.de

OEM New England

September 20-21
OEM New England
DCU Center in Worcester, Massachusetts USA
www.canontradeshows.com

October 2-4

SME Motorsports Conference & Exhibition
Charlotte, NC USA
www.sme.org

W6

October 8-11
Working With Wood Machinery and Equipment Exhibition
NEC Birmingham, UK
www.w6exhibition.com

MWC

October 10-13
Metal Working China 2006
Shanghai New International Expo Centre
Shanghai, China
www.metalworkingchina.com

CONCRETE SAWING & DRILLING ASSOCIATION

November 2-3
CSDA Cutting Edge Training
November 4
OSHA Construction Safety Training
November 6-7
CSDA Estimating Course
St. Petersburg College Clearwater, FL
USA • www.csda.org

AEROSPACE TESTING EXPO2006 NORTH AMERICA

November 14-16
Anaheim Convention Center
Anaheim, CA USA

FABTECH INTERNATIONAL & AWS WELDING SHOW

October 31 - November 2
Georgia World Congress Center
Atlanta, Georgia
www.sme.org/fabtech

CALENDAR EVENTS for 2007

WORLD OF CONCRETE
WORLD OF MASONRY | TECHNOLOGY FOR CONSTRUCTION

January 22-26, 2007
Las Vegas Convention Center
Las Vegas, NV USA
Tel: 866-962-7469
www.worldofconcrete.com

AEROSPACE TESTING EXPO2007 EUROPE

March 27-29
New Munich Trade Fair Center, Germany
www.aerospacetesting.com

2nd International Industrial Diamond Conference
19-20th April 2007 Rome Italy

April 19-20 2007
Diamond at Work
Rome, Italy
www.diamondatwork.com

APRIL 22-23, 2007
Industrial Diamond Association of America
Annual Meeting
Aladdin Resort & Casino
Las Vegas, Nevada USA
www.superabrasives.org

INTERWIRE TRADE EXPOSITION

May 5-10, 2007
Interwire 2007
I-X Center, Cleveland, Ohio, USA
www.wirenet.org

CALENDAR EVENTS for 2008

FEBRUARY 2008
Industrial Diamond Association of America
Annual Meeting
www.superabrasives.org

INTERTECH 2008
An International Technical Conference on Diamond, Cubic Boron Nitride and their applications.
ORLANDO FLORIDA USA
www.intertechconference.com

MAY 19-21, 2008
Orlando, Florida USA
www.intertechconference.com

IDA 60th Annual Meeting

The 60th Anniversary Celebration and Annual Meeting of the industrial Diamond Association of America (IDA) was held this past April in Atlanta Georgia. The General business meeting provided some excellent discussion on IDA programs and finances. The attendees felt that more companies should get involved in the statistics program and that this is a vital and valuable program only offered to IDA Member companies. Ion Benea, the new Standards committee chair is also working on updating the current standards overview literature. In addition to the reports of the tremendous success of INTERTECH 2006 the attendees discussed what they would like to see at INTERTECH 2008 in Orlando. Much conversation and attention was also given to the training programs being developed jointly by the IDA and SME. Everyone felt this would be extremely important for proper use of superabrasives in the industry. Keith Reckling and another outstanding presentation on current global economic conditions and future forecasting by Gina Martin from Wachovia Bank then treated attendees to an excellent day of technical and business presentations featuring an update of diamond recovery and hazardous material disposal. The IDA welcomed new Members Advanced Abrasives Corporation, Chardon Tool and Michael Werdiger.

At the 60th Anniversary Banquet the IDA new Officers and Board of Directors were inducted. Officers for 2006: **PRESIDENT** Robert Linares, APOLLO DIAMOND, INC. - **VICE PRESIDENT** David M. Simpson, SUMITOMO ELECTRIC CARBIDE DIAMOND GROUP - **SECRETARY/TREASURER** Martin Deakins, DIAMOND INNOVATIONS - **PAST PRESIDENT** Joseph W. Tabeling, DELAWARE DIAMOND KNIVES, INC. The new BOARD OF DIRECTORS, serving for the terms indicated are: Ion C. Benea (04-06) ENGIS CORPORATION - Maury Brassert (06- 08) TYROLIT WICKMAN INC., David L. Edwards (05-07) SYNTECH SUPERABRASIVES INC., Edward E. Galen (04-06) CINETIC LANDIS GRINDING CORP - CITCO PRODUCTS, Don Stropki (04-06) DARMANN ABRASIVE PRODUCTS, William J. Tully (06-08) DIAMOND ABRASIVES CORPORATION and R. Christian Winkel (06-08) WORLDWIDE SUPERABRASIVES. The evening also featured a special honor given to Rich Ladd as the IDA bestowed on him an Honorary Lifetime Membership. The nomination letter stated in part, “Rich Ladd has been a longtime active member of the IDA and has served the industry in many ways over his long career both with GE Superabrasives and Sumitomo Electric Carbide, Diamond Group. Rich had distinguished terms, both as a Director of the IDA and as an Officer and President. He was also pivotal in the creation and guidance of the INTERTECH conferences that have become flagship conferences for technical and application developments.” A great time was had by all, and plans are underway for the Annual Meeting in 2007 that will be in Las Vegas, Nevada… we look forward to seeing all members there!

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April 24-26, 2006

Conference Review

"See you in Orlando in 2008!" was the farewell most of the 250 attendees of **INTERTECH 2006** had for each other as they parted ways in Atlanta. This was a true sign of the overwhelming success of the third offering in the **INTERTECH** series. Attendees of **INTERTECH 2006**, held April 24-26 in Atlanta Georgia, USA were treated to three days of excellent technical presentations, enlightening keynote speakers and networking opportunities that one prominent figure described as "the best he had ever encountered". The conference attendee list was as impressive as the speaker list with dignitaries and leaders from major commerce and academia from around the world providing outstanding interaction and joining in discussion on topics from every technical session.

There were 60 papers presented which were selected from almost 90 submitted abstracts on topics ranging from a revolutionary cBN vapor deposition coating for cutting tools by Dr. Ajay Malshe to rapidly grown diamond crystals by Dr. Chihshiue Yan of the Geophysical Laboratory, Carnegie Institution of Washington. The variety and excellence was noted by the rave reviews. **INTERTECH 2006** offered 6 Keynote speakers, one in the morning and one after lunch, for each day. These speakers represented Boeing Aerospace, Delphi, 3M, Vanderbilt University, Georgia Institute of Technology and Cinetic Landis Grinding Corporation and each gave an insightful look into the future of superabrasive applications and industrial needs for the coming years. Three days of concurrent sessions saw attendees from 20 different countries enlightened and informed about the most critical and impressive technology related to superabrasives and their applications. Sessions were dedicated to aerospace, automotive, emerging technology, superabrasive innovation, electronics, optics, mining & drilling as well as stone & concrete. We learned about micron diamond, its use and various forms. We heard about machining products, laser cutting of polycrystallines, cubic boron nitride advancements, large crystal development, natural diamond uses, new concepts for CVD diamond, sawing products, ways to make current processes more effective and drilling innovations just to mention a few. Yes, **INTERTECH 2006** had a little bit of every technology to whet the appetite of those seeking to learn and grow. We were even given a rare look at the US Government Diamond Stockpile workings and a very informative review of the Chinese diamond industry by Dr. Li Zhihong, the General Secretary of the Industrial Diamond Association of China. The varied subjects and different opinions generated much discussion and a few very energetic question and answer sessions.

As an added bonus, many companies took the opportunity to exhibit their products at one of the conference tabletop displays. Those who participated in this activity came away with very positive comments on the contacts they made, citing this was a very useful experience and a great way to initiate meaningful dialogue. The venue of the Grand Hyatt was an excellent setting with outstanding meeting facilities. Many attendees pointed out that the ease and comfort in networking was aided by the fine cuisine, excellent service and many amenities provided at the conference. The **INTERTECH** staff has already started planning **INTERTECH** 2008 that will be held May 18-21, 2008 at the Contemporary Resort in Walt Disney World, Orlando Florida, USA. Details on all **INTERTECH** conferences, including complete attendee lists and the technical programs can be found at www.intertechconference.com.

THE FOLLOWING PAGES ARE EXCERPTS OF SELECTED PAPERS FROM INTERTECH 2006. DUE TO THE MANY HIGH QUALITY PAPERS ONLY A FEW COULD BE HIGHLIGHTED, BUT ALL PAPERS CAN BE FOUND ON THE INTERTECH PROCEEDINGS CD AVAILABLE FOR ORDER AT WWW.INTERTECHCONFERENCE.COM

CVD Diamond The Cost Effective Solution to High Heat Flux Thermal Challenges

DWAIN A. AIDALA, President & COO, sp3 Diamond Technologies, Inc.

ABSTRACT One of the many outstanding characteristics of diamond is its high thermal conductivity. Some types of natural diamond can have thermal conductivity as high as 2000W/m-K. CVD diamond can be manufactured with thermal conductivities ranging from 1000W/m-K to 1800W/m-K. Many high technology applications are finding that performance growth is being constrained by thermal issues, with increased performance restricted by reliability or stability concerns. The electronics and communications industries continue to struggle with the challenges of thermal management. While new technology provides the path to smaller and smaller device geometries, this same scaling path further increases the difficulty of getting heat away from the active portions of the circuits.

This paper will address two diamond-based, high heat flux thermal management solutions developed by sp3 Diamond Technologies. While these technologies and manufacturing processes were developed and honed for cutting tool applications, the many unique characteristics of CVD diamond are applicable to technology applications as well. Additionally, the production processes developed to grow revenue and profits in the cost sensitive cutting tool market are enablers of cost-effective thermal management solutions.

The paper will discuss the transition of the manufacturing processes of freestanding diamond for cutting tools to the productization of heat spreaders. The paper will also discuss how the technology developed for thin film diamond for round tools and inserts serves as the foundation for work in diamond-on-silicon (DOS). DOS will be the enabling layer for the development of active circuits with thermal heat spreading as part of the basic device. Finally, the paper will provide an overview of the future "hot spots" in thermal management.

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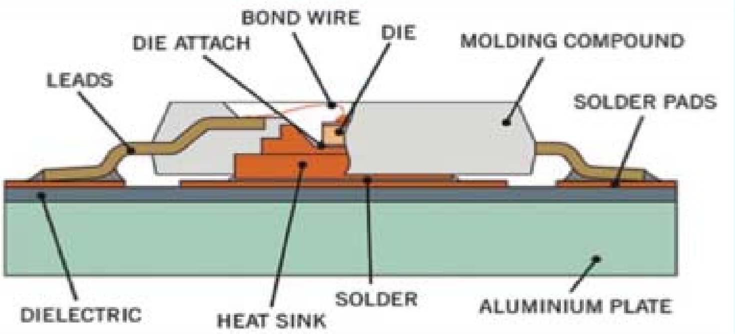
Typical LED Thermal Management Assembly



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Orientation Dependence of Diamond on Wear Resistance and Its Application to Improvement of Dresser

KOBAYASHI, Y, OHARA, T and NAKASHIMA, T
Sumitomo Electric Hardmetal Corp.

Key Word: Diamond, Orientation dependence, Wear resistance, Dresser

Crystal dependence of diamond on wear resistance was measured. It was found that (110) <110> or (211) <111> were the most preferable directions for dresser, even though dressing direction in conventional dresser is (100) <110> in common usage. On the basis of these results new type of dresser was designed. Proposed diamond dresser was stick-shaped of which end face were (110) or (211). Dressing performance of the new designed dresser was excellent compared with conventional dresser in wear resistant rate and stability.

1. INTRODUCTION

Diamond is the hardest material; therefore it is the most wear resistant material. Utilizing this property diamond is used for wire drawing die, cutting bite, dresser, etc. However wear resistance heavily depends on crystal orientation. This anisotropic feature usually has a negative influence on the applications to wire drawing die (anisotropic wear) and cutting bite (orientation constrains in shapeforming). In contrast, for some applications like a dresser, they can be designed for excellent performance in wear resistance if once proper orientation of diamond crystal is selected. Therefore it is necessary to understand orientation dependence on wear resistance to elicit highest performance from diamond.

In the past, there were many works to measure wear resistance of diamond crystal [1-3]. All of these works were done using natural diamond, of which crystalline quality and amount of impurity varied from stone to stone. In addition, grinding conditions in the previous works were much different from those when diamond is used as dresser. At that point, diamond was polished with micron powder of diamond on skive disk, while, diamond dresser is used for dressing, tooling and forming of GC(green carborundum) , WA(white alundum) or CBN (cubic born nitride) grinding wheel. In this report wear resistance of synthetic diamond was measured quantitatively in terms of orientation dependence. Wear resistance test was done by grinding with diamond wheel. This grinding condition was close to the one for real application of diamond dresser. Based on the experimental results, new design of diamond dresser was proposed. Comparisons of performance between new designed and conventional dresser were carried out in regard to wear rate and stability. Comparison of dresser performance between single crystal diamond and CVD diamond was also reported here.

2. MEASUREMENT OF WEAR RESISTANCE

2-1 Experimental

Rectangular solids (0.8x0.8x3.0 mm3) with end face of (100), (110), (211) and (111) plane were prepared using synthetic diamond. Each solid was ground with metal-bond diamond wheel (Allied Diamond #800) in the wheel speed of 50m/sec. under dry condition for 2 minutes. Pressing load was 0.5kgf. To prevent initial chippings or no uniform wear, some pre-dressing on the testing surface was put to make it smooth. Wear length was measured after grinding for each plane changing dressing direction on the plane. Hereinafter "(110) <110>" denotes <110> direction on (110) plane for convenience sake.

2-2 Result and Discussion

Comparisons of wear volume in various directions on each plane were shown. The results were almost consistent with the previous works. However, it was notable that wear resistance of (110) <110> was better than (100) <110> in the present work, while, the results were opposite in the previous works. The reason was not well explained, but it could be possible that this difference was due to the difference of crystals used for experiments (synthetic/natural diamond) or due to the difference of grinding conditions between the present work and the previous ones. This time wear resistance of (211) plane was measured for the first time. We found that wear resistance on (211) <110> and (211) <110> are then highest next to (111) plane.

3. APPLICATION TO DRESSER

3-1 Design of New Dresser

Conventional dressers are shown in Fig.2 schematically. Natural diamond is commonly used for conventional dressers and its dressing direction is usually (100) <110>. According to our experiments (100) <110> is not the best direction. In addition, working area varies as wear progresses because of octahedral shape of natural diamond in single point type or crystal pullout during use in multi point type. This means that dressing performance of conventional dresser is unstable both in single point and multi point.

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Diamonds For Life

By: STEVE ROFFMAN, Lieber & Solow Company and
BARRY WALKER, Henri Polak, Diamond Corporation

Good Morning Ladies and gentlemen, my name is Steve Roffman. This year, together with my partner, Michelle Lieber of Lieber and Solow Ltd., we have joined hands with Barry Walker and Nicole Polak of the Henri Polak Diamond Corporation to prepare today's presentation. From the unique perspective of being two of the world's oldest and largest natural industrial diamond suppliers, we would like to share with you a story that is so fascinating and unknown, it takes people by storm. Which story do I mean? Why, the Industrial Story, the story of Diamonds for Life.

Today, modern manufacturing methods and new products require high performance and close tolerances. Consequently, the use of natural diamond tools has expanded to meet these new processes and requirements, while still maintaining its traditional role in manufacturing. Many of the consumer products, medical devices and transportation methods crucial to our everyday lives are touched by natural diamond. Today, we'd like to show you where natural diamond fits into the modern world.

First, let us give you an overview of today's presentation:

1. The Ripple Effect – How the relatively small business of natural industrial diamonds makes such a big impact on the world.
2. Why Natural Diamond? – The products that benefit from intrinsic properties of natural diamond.
3. A Current Market Snapshot – The state of the rough diamond market today, from mines to machines.
4. Questions

Within the last year, everyone in this room has flown on an airplane, driven a car, taken a train or a boat. Every one of us has used a computer, talked on a cell phone, downloaded, up linked and hot synched. Some of us have had surgical procedures.

Some of us, or our loved ones, may even have pacemakers or stents keeping us going. All of these things are essential to modern life. And diamonds, natural industrial diamonds are now, more than ever, an essential element in making all of these things possible. The impact of natural diamond usage is far reaching and significant. It is the case of the Big Ripple made by the small stone – or, the Ripple Effect. The natural industrial diamond business is a small part of the global rough diamond business. It is also a relatively small part of the global superabrasive business. Nevertheless, it is a significant and essential element of our industry. From each single diamond and from each range of materials, tools and devices are created which impact a production line, or a medical application, or a scientific research project or mining or construction operation. From high tech industries to simple grinding, the impact of natural diamonds is impressive. Step by step, natural industrial diamonds help create the products and processes which touch all of our lives every day.

How does this happen? Well, to help answer that question, I'd like to introduce Barry Walker. With over 40 years of experience, beginning as a diamond tool manufacturer and for more than 20 years now as an industrial dealer, Barry brings knowledge and clarity into the very real ways natural diamonds impact us all. We can say without question that natural diamonds are used in the manufacture of just about anything with wheels or an engine and drive train. They are an essential part of the global transportation industry.

Just last year, world-wide automobile production exceeded 64 million units valued at over $1.3 trillion.

The US aerospace industry produced a record $170 billion worth of aircraft in 2005, with over half delivered to the Department of Defense and NASA. Natural diamond tools were used to true and form the abrasive wheels that ground the engine and drive train components of these modes of transportation. In addition, wire dies made with high quality natural diamonds were used to produce precision wire for the electrical and communication systems.

As a point of interest, just one Boeing 747 has over 100 miles of wire winding through its skeleton, much of it produced or at least finished with natural diamond dies.

These are just three examples of the staggering volume of the global transportation industry that relies, in part, on natural diamonds, and only begins to show how they impact our daily lives. Natural diamond dies are used to produce tungsten wire for light bulb filaments, electrical systems for planes, trains, boats and automobiles, computer and electronic components and medical devices. Most tungsten, stainless steel, fine copper and gold wire is produced with natural diamond dies. In addition, natural diamond dressing tools are used to true and form the wheels that grind precision bearings that are an integral part of every piece of machinery with moving parts.

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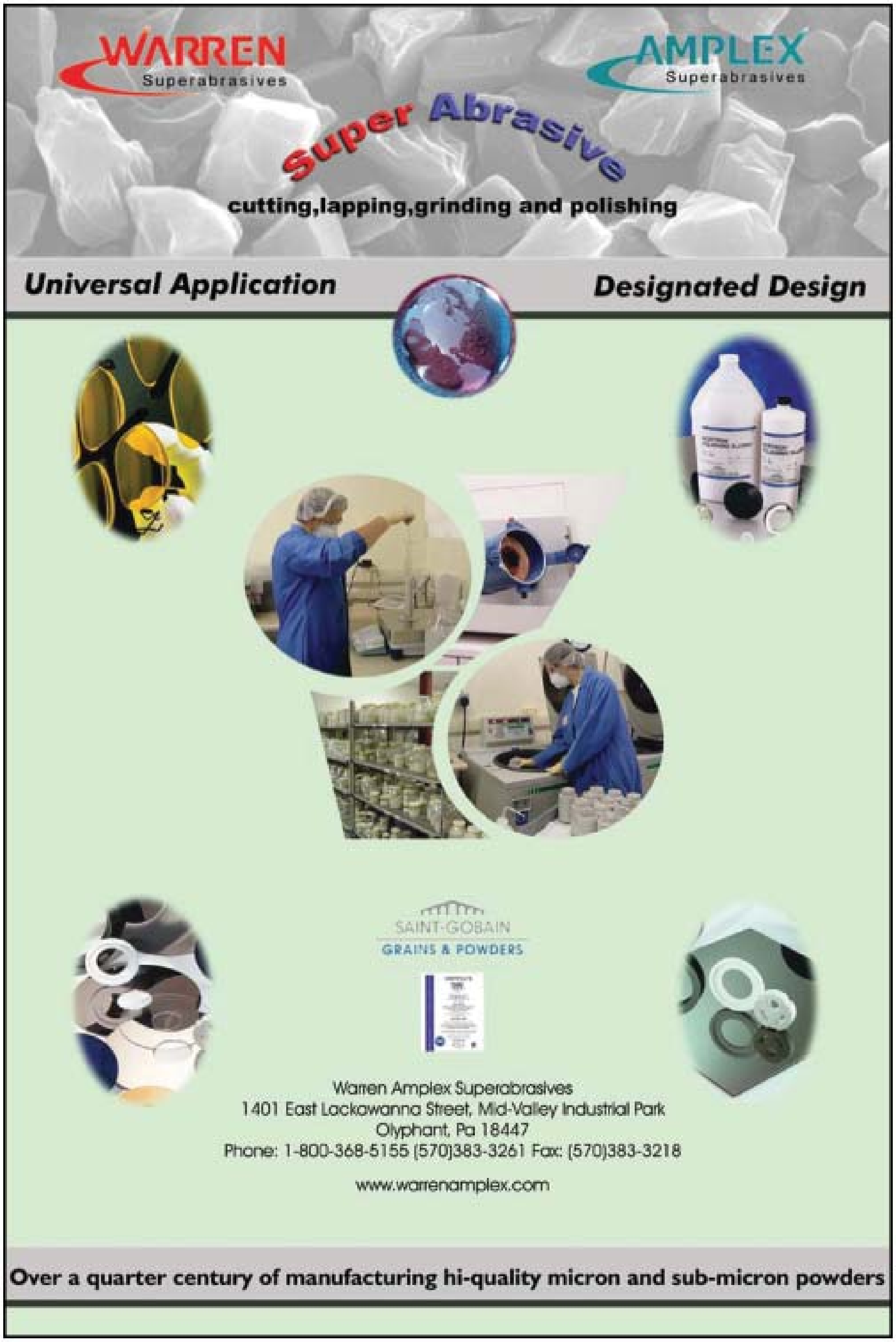
Superhard Polycrystalline Materials in Metal Cutting Applications

C. LAHIFF, J. BARRY, N. PRETORIUS
Element Six Ltd., Shannon, Co. Clare, Ireland

As environmental issues and cost efficiency remain the focus of the automotive and aerospace industries the range of metal alloys, cast irons and powdered metals being used in industry continues to increase. Many of these new materials are developed to meet specific requirements such as weight reduction, increased strength, corrosion and heat resistance. However, it is not always immediately possible to achieve these extreme properties and retain good machinability. Superhard cutting tool materials such as polycrystalline diamond (PCD) and polycrystalline cubic boron nitride (PCBN) very often provide the most effective solutions to these new machining challenges. This paper presents a review of some of these difficult-to-machine materials and shows how PCD and PCBN can successfully perform in such applications.



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1. INTRODUCTION

1.1 Polycrystalline Diamond (PCD)

Today, one of the biggest markets for PCD cutting tools is the metalworking industry with the primary demand coming from the automotive and aerospace industries, which require high precision tools to achieve extremely high dimensional tolerances and surface finish requirements on parts. The most common metals being machined with PCD are aluminium alloys, metal matrix composites and more recently titanium alloys, glass fibre reinforced polymers (GFRP) and magnesium alloys. These materials are being used in an everincreasing range of parts, primarily due to the requirement for lightweight components [1]. Aluminium casting applications in the automotive industry have been on a growth curve for several years now and this trend is likely to continue. The biggest growth areas are engine blocks, cylinder heads, wheels, and brake and suspension parts [1,2]. High silicon-aluminium alloys, such as 18%SiAl are expected to grow in applications such as internal combustion engine blocks and cylinder bodies for compressors [2]. Changes in European regulation on CO2 emissions has put increased emphasis on the reduction of the overall weight of vehicles and an improvement in the efficiency of the powertrain. The result is an increase in the use of compact graphite iron (CGI) and austempered ductile iron (ADI) as replacements for lower strength-to-weight materials, such as steel and grey cast iron. A new generation of fine grain and multimodal (more than one grain size) PCD materials are meeting the challenge of providing machining solutions for high strength cast irons.

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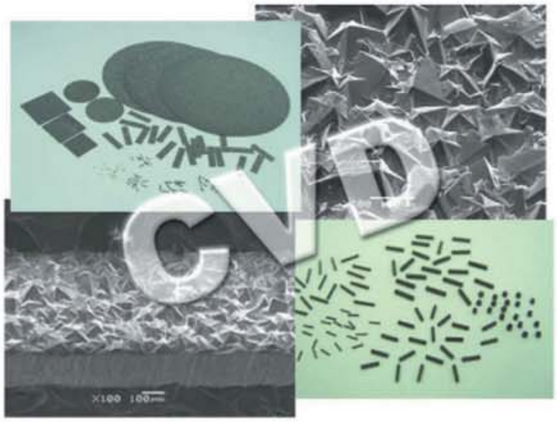
Disc Sizes 60MM & 75MM Diameter



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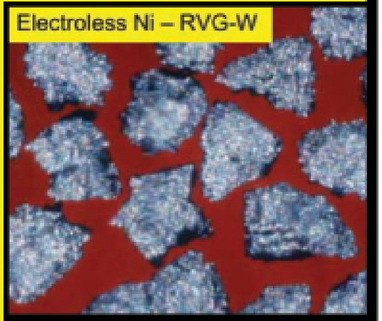
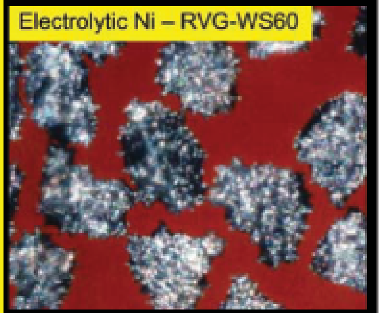
Selecting Superabrasive Coatings for Improved Tool Performance

SRIDHAR KOMPELLA
Diamond Innovations

Superabrasive tool performance can be demonstrably improved by use of coated crystals which aid in improved grain retention or protect the crystal from degradation or both. However, matching a coated superabrasive to the appropriate application is essential to realizing any performance benefits. In this paper we analyze the coatings process induced effects on diamond crystals. Mere similarity in nominal coating chemistry is usually an insufficient measure of the utility of the coating. A study is conducted on the chemical nature of commercially available coatings. We demonstrate that poor coating process control can result in a substantial loss of diamond toughness before it is subjected to an elevated temperature tool fabrication procedure. Further, we also study the characteristics of coatings obtained by different vapor deposition processes and examine their suitability in material removal applications.

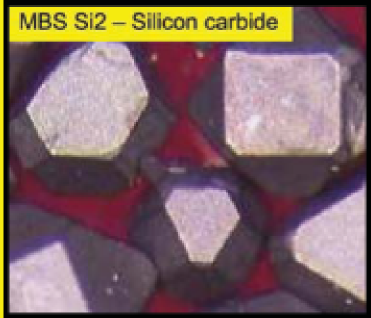

Electroless Ni – RVG-W


Electrolytic Ni – RVG-WS60

Electroless Ni – MBS-SB

MBS Ti2 – Titanium carbide

MBS Cr2 – Chromium carbide


MBS Si2 – Silicon carbide

1. Introduction

The high hardness and abrasion resistance of synthetic diamond and cubic boron nitride enable them to perform at vastly superior material removal rates compared to conventional abrasives while ensuring substantially longer tool life. The economics of the superabrasive tool, however, require that the crystals be used optimally to the end of their useful life while avoiding any premature crystal pullout or inordinate crystal crushing. Analysis of used tools can assist in tool improvement by guiding the optimization of the tool composition – the bond and crystal – around the needs of a specific application.

For a tool that is wearing ideally, the fraction of lost crystals (the pullout sites) should not be excessively large compared to the number of active, whole crystals and crushed crystals. A large fraction of crushed or polished crystals indicates either the unsuitability of the abrasive grade or points at an inappropriate combination of crystal mesh size and concentration.

However, in a tool comprising the right superabrasive grade and concentration, a large number of deep pullout sites (Fig. 1a) hints at a poor interaction between the crystal and the bond. The absence of any chemical alloying between a resin or metal bond and the superabrasive (diamond or CBN) can leave the crystals vulnerable to premature pullout. Anchoring of the crystal by the encapsulating resin or metal bond alone could prove insufficient to retain the crystal as it wears. In contrast, Fig. 1b shows an example of a worn tool surface with well-exposed whole crystals that are likely engaged in material removal.

Further, in metal bonds, the use of less-expensive but chemically reactive or catalyzing metals can aid in the degradation of abrasive toughness during tool processing. Such weakened crystals can result in an undesirable distribution of crushed sites on the cutting surface of the tool, which in turn results in poor tool performance. Thus, there is a well-recognized need for maintaining the toughness of the crystals in a bond while retaining the working crystals for as long as possible. Coated superabrasives offer a solution for these challenges.

2. Coated Superabrasives

The benefits of coated superabrasives are two-fold. Under the appropriate processing conditions, they can aid in crystal retention and provide protection, both chemical and thermal.

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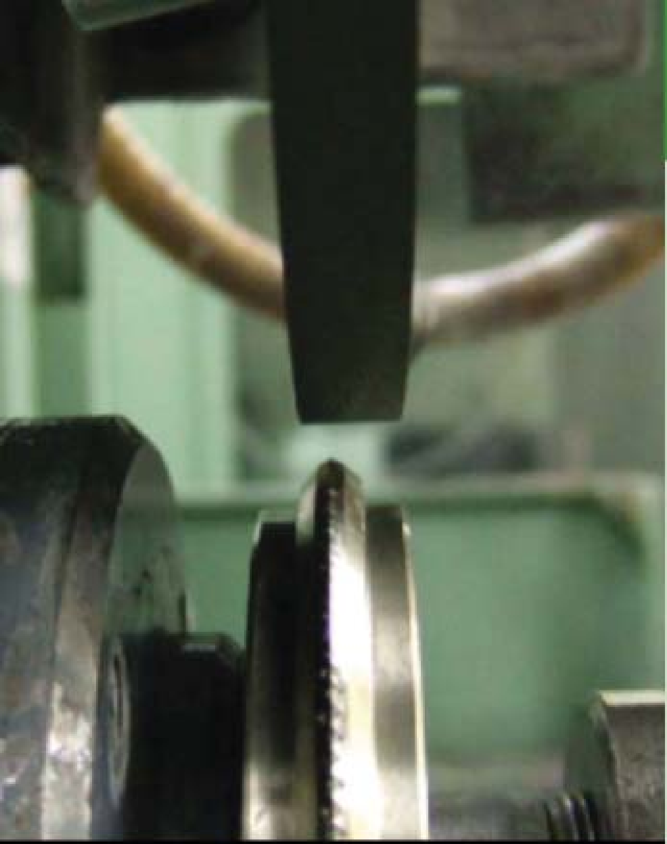

High Speed Grinding with CBN Wheels Utilizing Wheel Core Expanded by Centrifugal Force

By: NORIHIRO FUNAYAMA, JUNICHI MATSUDA
Asahi Diamond Industrial Co., Ltd

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1. Background

Vitrified CBN wheels are widely used in High Speed Grinding Applications in order to achieve higher productivity. Our group defines High Speed Grinding as 100m/sec or faster, with a material stock Removal Rate of 50mm3/s _m. It is crucial to address and to incorporate wheel core expansion during the design phase, because it directly relates to the part quality as well as to operator safety. By the optimization of the high speed wheel core design, remarkable results can be expected and seen. As known, the performance of a Vit CBN wheel is controlled by changing the dressing parameters, which we will show a relationship between performance and the dressing condition.

Our team carried out the tests on following matters.

I. **Finite Element Measurement (FEM) Analysis of Optimum Wheel Design to suppress wheel core deformation**

II. **Relationship between Vit CBN performance and dressing condition**

2. FEM Analysis of Optimum Wheel Core Design to suppress the deformation

2-1. Wheel core configuration - Stress

When the wheel core is accelerated to high speeds, it incurs centrifugal force that causes stress and displacement of the wheel core, which impart may cause part quality deterioration issues including wheel core cracking and ultimately breakage. We analyzed the relationship between the wheel core design, and the stress of the wheel core displacement using FEM design analysis in order to optimize the wheel core design.

2-2. Taper Wheel Core Design

In order to keep thicker abrasive section, the tapered core design below, TAPER – A was FEM analyzed for the displacement and the stress.

2-3. Verification of FEM analysis and simulation data

Our team carried out actual spin test to verify the FEM analysis measurements. Figure 6 shows our spin test equipment that is capable rotational speeds up to 40,000 revolutions per minute and the laser gap sensor used to measure the expansion of wheel cores tested.

3. Dressing Vitrified CBN to Obtain desired Part Finish

3-1. Dressing Vit CBN using a Diamond Rotary Dresser

The conditioning and truing of Vit CBN wheels is very dependant upon the method of dressing. Most of the time such important dressing factors are actually decided empirically in the field. We will examine the mechanics of dressing by checking the surface topography of the CBN grains as well as the surface finish off the

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Nano Clustered Diamond – Characterization of Properties

BENJAMIN R. ROSCZYK, LAURA M. NAGLE and ION C. BENEA, Ph.D. • Engis Corporation

1. Abstract

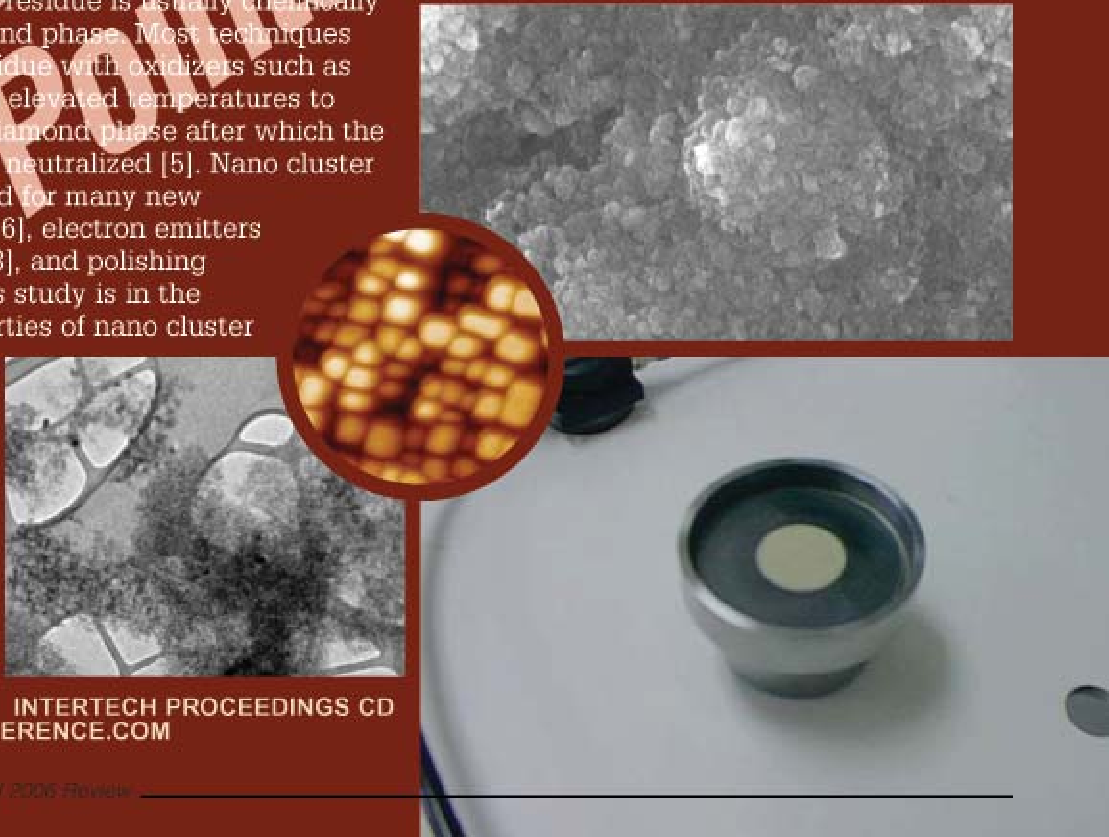
Nanometer size diamond is becoming a product in high demand for many different industrial and electronic applications. Particularly, the nanometer size clustered diamond (nano clustered diamond) is the preferred diamond type for texturing of magnetic media. The unique properties of nano clustered diamond are responsible for its superior performance in disk texturing applications. Characterization of nano clustered diamond with respect to its macroscopic and microscopic properties represents an important step toward addressing the main challenges of media texturing: extremely low surface roughness coupled with very low scratch level. The characterization of nano clustered diamond involves measuring particle size, shape, surface area and mechanical strength using the following investigative techniques: PSD determination, TEM/SEM/AFM analysis, BET analysis and mechanical strength testing.

2. Introduction

The synthesis of nano cluster diamond or nanodiamond (ND) was discovered three times by different researchers over a period of 19 years in the former USSR [1]. Recently, the unique properties of this material have revived interest in its study.

Nano cluster diamond consists of very small crystallites (<10nm) tightly bonded in small clusters (15-40nm) which are loosely agglomerated into porous particles with a high surface area [2, 3, 4]. Nano cluster diamonds are synthesized by explosion of a chemical compounds in a confined space with a negative oxygen balance. The confined explosive energy creates high temperature and pressure for a very short period of time in which carbon supplied by the explosive compound nucleates small diamond crystals. Due to the relatively short period of high temperature and pressure, significant growth of crystallites does not occur and a mixture of small crystallites dispersed in amorphous carbon results. If the explosive residue is cooled quickly enough, kinetic restraints will prevent the thermodynamically favorable conversion of diamond into graphite. The cooling rate is largely controlled by the surrounding medium in the explosion chamber, and media with high specific heat such as water or ice tend to produce a higher yield of diamond than the slower cooling inert gas atmospheres such as nitrogen or carbon dioxide [5].

The diamond/graphite explosion residue is usually chemically cleaned to remove the nondiamond phase. Most techniques involve mixing the explosion residue with oxidizers such as nitric acid under pressure and at elevated temperatures to preferentially dissolve the non-diamond phase after which the diamond phase is separated and neutralized [5]. Nano cluster diamonds have been investigated for many new applications including catalysts [6], electron emitters [7], incorporation into coatings [8], and polishing applications [9]. The focus of this study is in the structural and mechanical properties of nano cluster diamond. Techniques such as TEM, XRD, and AFM were used to characterize the structure of a specific commercial nano cluster diamond and a novel powder crushing technique used to qualitatively describe its crushing behavior.



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Characteristics of High Strength CBN at HIGH SPEED GRINDING

Seung-Woo Nam,
Grit R&D Team/Manager,
ILJIN Diamond Co., Ltd.

CBN is widely used to process ferrous materials where diamond can't be applied. As the industry advances new applications, demanding for faster grinding speed, with stronger/more abrasive work materials are developed. Existing CBN used for the general materials is not strong enough to give sufficient performance and machining ability to these demanding trends in the market. In this context, high speed grinding process is widely spreading to reduce the working time and grinding load. For instance, much faster grinding speed of over 100 m/s is being applied to machine work pieces, compared to standard grinding speed of 20- 40m/s. This needs of the market leads us to develop a new CBN capable of high speed grinding of hard-to-machine materials. In this paper newly developed material, CBN-5 (fictitious name), with higher toughness and blocky shape of well-developed facet similar to diamond will be introduced. In addition to that, some of the test results at high speed grinding process will be shown with CBN-5. Grinding test of vitrified wheel made of existing CBN and CBN-5 was performed to determine/measure tool life, grinding ability, surface quality after usage.

Introduction

Cubic boron nitride (CBN), being widely used in the field of processing ferrous materials, has some characteristics like the second highest hardness following diamond and high chemical stability. It is used in various processes, especially requiring high efficiency and precision more and more. Today grinding machines are being developed for high speed grinding to fulfill requirement for processing the recent super alloys and increasing efficiency of tools. In accordance with these needs, new tools and processing methods are being developed according as the above work pieces.

CBN-5, developed for these industrial needs, is new grade that maintains high hardness, generates continuous micro or nano chipping, and keeps high grinding efficiency under the high grinding force.

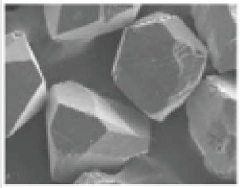
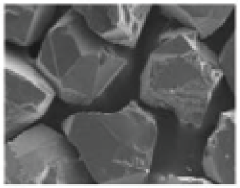
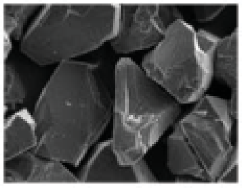
General CBNs have high grinding efficiency in the low grinding force or low power of a motor. In order to reduce grinding force, it's required to generate constant formation of new cutting edge with good fracture characteristic of CBN grit. Under the high grinding force, however, CBN particles can easily be broken and pulled out. If then, it is of no use for grinding. If such conditions occurred in succession, finally they can cause tool life abruptly dropped or overall grinding quality decreased because formholding ability of wheel comes down. Consequently, it can be said that it's very important to generate continuous cutting points and micro or nano fracture(selfsharpening), not macro fracture under the condition of high impact on particles, still keeping the toughness of CBN.

In this paper, after analyzing differences between new developed CBN with the existing CBNs, characteristics of CBN will be studied how the improved properties of CBN affect on wheel performance during the grinding process under the high load.

Features of CBN abrasives grits

Properties of CBN particles affecting grinding performance are such as toughness, fracture behavior and thermal stability. As was shown Table I, grinding test of 3 kinds of CBN was proceeded and analyzed. In the grinding process, a good grinding ability of CBN under high grinding force means that CBN particles have continuous self-sharpening behaviors. To figure out these characteristics, breakdown properties of CBN were tested in the different crushing conditions or 'Friability test', following by different force and impact. The test result is shown in Fig 2. As was shown Fig 2, toughness of IBN-5 is higher than those of other CBN products. As crushing condition is more severe, toughness difference is getting bigger. Even among the highest CBNs of competitors, CBN-5 is showing the best quality. While this characteristic is not outstanding under normal load conditions, toughness difference in high load will increase.

FEATURE OF EACH CBN ABRASIVE

	CBN-5	CBN-3	CBN-4
Color	Amber	Amber	Amber
Shape	 Blocky (like diamond shape)	 Blocky	 Angular (Sharp edge)
Toughness & Thermal Stability	Extremely high	Medium	Medium
Fracture behavior	Nano & Micro	Micro	Micro

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Fall 2006	Machine Tools & IMTS preview	July 31, 2006
Winter 2006/2007	Polycrystalline cBN and Diamond	Nov 30, 2006
Spring 2007	Superabrasives Resource Directory	Mar 31, 2006
Summer 2007	New Superabrasive Applications & Products	May 31, 2007
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HIGH-PRESSURE POLYCRYSTALLINE DIAMOND AS A COST EFFECTIVE HEAT SPREADER

Scott S. Dahlgren, H. Tracy Hall, Jr. • Novatek

ABSTRACT

Diamond is an ideal material for heat spreading applications. CVD PCD is many times more expensive than high pressure PCD because it grows much slower and the material cost is higher. High-pressure PCD can be produced in large quantities and molded into shapes at a reasonable price. Novatek's patented high pressure synthesis process produces PCD with a conductivity of 700 W/m°K, almost twice that of copper. Diamond heat spreaders are most effective in applications producing high heat flux densities. Diamond becomes far more conductive than metals at cryogenic temperatures. The thermal junction between the IC and the heat sink is a predominant thermal resistance. High pressure diamond has favorable thermal expansion and stiffness coefficients and is easily pre-metalized insitu, making it a good material for direct bonding to the IC.

KEYWORDS

Diamond, heat spreader, power density, flux density, thermal conductivity, Chemical vapor deposition, CVD, poly crystalline diamond, PCD, semiconductor, processor, IC

NOMENCLATURE

A	cross sectional area	**PCD**	poly crystalline diamond	**m**	meter
C	degrees centigrade	**Q**	heat flux	**mm**	millimeter
CVD	chemical vapor deposition	**T**	temperature	**w**	watt
K	degrees Kelvin	**k**	thermal conductivity	**x**	distance between temperatures

BACKGROUND

As IC clock speeds and power densities have continued to increase, the need arises for more efficient and cost-effective materials to remove heat from the IC. Polycrystalline Diamond (PCD) sintered at high pressure and high temperature is an ideal material for this application. PCD is and engineered material that can be tailored to a wide variety of applications. For example, PCD can be formulated to optimize its heat transfer characteristics and PCD heat spreaders can easily be produced in any number of three-dimensional shapes so that they can be cost-effectively tailored to the package layout of the IC.

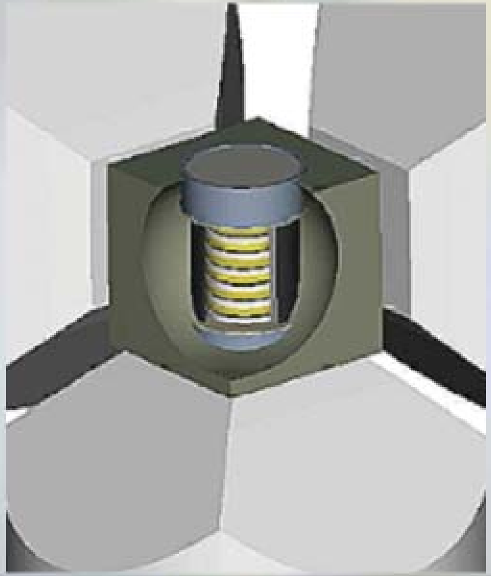
PCD could be used as a replacement in applications where reliability or noise restricts the use of cooling fans. High-pressure polycrystalline diamond is also a mature product that can be produced in the high volume required by the semiconductor industry.

The semiconductor industry has applied considerable effort toward improved cooling of high performance electronic devices. Diamond is a very attractive material to the semiconductor industry because it has the highest thermal conductivity of any known material and has a very high electrical resistance (1018 ohm-m) and high band gap (5.48 eV).

Diamond's coefficient of thermal expansion is also very low (1.1 ppm/K @ 300K), allowing it to be bonded to directly to a silicon IC, and it is thermally isotropic in both single and polycrystalline high-pressure synthesized forms.

There are four categories of diamond:
1. Natural (gemstones)
2. High-pressure synthetic diamond
3. Chemical vapor deposited, or CVD diamond,
4. Diamond-like carbon, or DLC

As illustrated in Table 1, diamond is classified into four types. Synthetic diamond falls into two of these categories. There is a wide variation in thermal conductivity within each type due to individual variations in purity. In metals, heat is conducted primarily through electron transport, but in an electrically insulating material such as diamond, heat is conducted through lattice vibration, by the flow of phonons. Because of this, anything that decreases the mean free



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Friction stir welding using polycrystalline cubic boron Nitride and polycrystalline diamond for high melting temperature materials

RUSSELL J STEEL, SMITH MEGADIAMOND, SCOTT L. HORMAN – Smith MegaDiamond
TRACY W. NELSON – Brigham Young University • CARL D. SORENSON – Brigham Young University • SCOTT M. PACKER – Advanced Metal Products

Friction stir welding (FSW) is a relatively new joining process invented by The Welding Institute in 1991. FSW is a solid state welding process in which a rotating nonconsumable tool is translated along the interface between two materials to be joined. The tool consists of a protruding pin, which is plunged into the work pieces, and a larger shoulder section, which is maintained on the surface of the joint. Frictional heating generated by shoulder and pin rotation in contact with the base material produces a local plasticized region around the tool. As the tool is traversed along the weld joint, plasticized material is displaced around the tool. Because of the high amounts of deformation and the large forging pressures applied by the tool shoulder, a full metallurgical bond is produced. FSW produces a wrought microstructure and offers significant benefits in mechanical and corrosion properties as compared with more traditional welding methods. Though initially developed for low melting temperature alloys, recent development of new tool materials such as polycrystalline cubic boron nitride (PCBN) and polycrystalline diamond (PCD) has expanded the application of FSW into high melting temperature materials such as steels, stainless and duplex stainless steels, nickel base alloys, and abrasive materials such as metal matrix composites (MMC). This paper will present an overview of weld properties and microstructure of various friction stir welded materials along with grade development of ultrahard materials for use in FSW tools.

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BACKGROUND

Friction stir welding was developed and patented by The Welding Institute (TWI) in England in 1991 (Thomas et al, 1993). FSW is a solid state welding process in which a rotating nonconsumable tool is translated along the interface between two materials to be joined. The tool consists of a protruding "pin", which is plunged into the work pieces, and a larger concentric "shoulder", which is maintained on the surface of the joint. The shoulder consists of a concave surface, which produces a combination of frictional heating and forging pressure. The process is a solid state joining process in which melting does not occur during the welding process. Welding parameters for FSW consist of the rotational speed of the tool, the forging pressure applied by the tool, and the travel speed of the tool with respect to the base material. These parameters are governed by the tool geometry (i.e. shoulder and pin diameter), mechanical properties of material to be joined (i.e. flow stress), and material thickness.

Frictional heating produced by shoulder and pin rotation in contact with base material produces a local plasticized region around the tool. As the tool traverses along the weld joint, plasticized material is displaced around the tool. The high degree of deformation and the large forging pressures applied by the tool shoulder, produce a full metallurgical bond.

As a solid state welding process, FSW is not susceptible to typical solidification defects such as porosity and hot cracking that are common in arc welds. Microstructurally distinct regions are characterized much like those in arc welds. These include: A) the unaffected base material, B) heat affected zone (HAZ), C) thermal mechanically affected zone (TMAZ), and D) the stir zone (SZ), or weld nugget. The SZ consists of fine equiaxed grains. Recrystallization has occurred in order to relieve the high amount of plastic strain introduced by the FSW process. Adjacent to the SZ are the TMAZ and HAZ regions. The TMAZ is distinguished by an elongated plastically deformed grain structure. Grains in this region have been deformed at an elevated temperature by the formation of the SZ (Ditzel, 1997; Mahoney et al, 1998; Rhodes et al, 1997). The HAZ is the region outside of the weld, which has undergone a thermal cycle from the welding process. There is also an advancing and retreating side of the weld associated with FSW. The side of the weld in which the tool rotation and the travel direction is in the same direction is considered the advancing side. The side of the weld in which the tool rotation is opposite of the travel direction is considered the retreating side. Distinct microstructural features are present in these areas depending upon the material being joined, FSW tool geometries, and the welding parameters.

Many aluminum alloys previously considered as unweldable have exhibited excellent mechanical properties through FSW (Rhodes et al, 1997; Mahoney et al, 1998; Mishra et al, 2000). The aerospace industry has aggressively pursued the application of this technology to capitalize on the technical benefits and cost savings. Recently, the FAA has approved FSW for use on the Eclipse 500 corporate jet, and the

EFFECTIVE CLEANING METHODS AND BEST PRACTICES OF SYNTHETIC INDUSTRIAL DIAMOND

RON ABRAMSHE, PH.D.

Synthetic diamond is used as a super abrasive in many industries, from electronics to medical applications. These industries as well as others require cleanliness of the base product as paramount to a quality end product. One should understand some basic facts about synthetic diamond in order to grasp a better understanding of its abrasive application within the industrial sector. The following is a rudimentary narrative of the synthetic diamond synthesis process.

SYNTHETIC DIAMOND

In synthetic and natural diamond, impurities exist and are known as inclusions. They appear as dark spots, dispersed clouds or opaque sections and are composed of many basic elements as hydrogen, nitrogen, oxygen boron, magnesium, aluminum, silica, calcium and other trace elements. Impurities that occur in synthetic diamonds are elements resulting from other metal catalysts used in production. Main catalysts are a combination of nickel, iron and cobalt. Other impurities in synthetic diamonds are mainly from the high temperature, high-pressure (1,800 deg. C at 25 - 30GPa) reaction chamber and post processing.

Elements that are commonly monitored in synthetic diamond are aluminum, calcium, cadmium, cobalt, chrome, copper, iron, potassium, magnesium, manganese, sodium, nickel, silica, tantalum, vanadium, zirconium, zinc and boron. Each of these elements play a role in the end use of the synthetic diamond and the quantity of impurities allowed—depending on the intended end use.

It should be noted, however, that the intended use is as critical as the materials that are being used in part of the overall manufacturing process. In many cases, the base material—synthetic diamond, can cause down stream processing problems for manufacturers. In simplistic terms, it is never good to eat from a dirty plate.

Let's look at some of the reasons why the purity of a diamond surface is important.

CLEANED MESH OR MICRON DIAMOND

The need for surface cleaned mesh or micron diamond is paramount to post-processing and for final products. The reasons for this can briefly be described as follows. Surfaces that contain certain levels of iron or other magnetic metal impurities can create problems in a Nickel or Copper electroplating operation. Synthetic diamond containing too much iron will make it magnetic, which in turn, will result in the diamond attaching to itself instead of the plating, chemical. The final results are the formation of agglomerates that decrease yield or cause an oversize condition on the final product. Both are undesirable. Diamond that contains too much calcium impurity will leave calcium deposits in a lapping operation that will be difficult to remove. The deposit will require an additional cleaning removal step—resulting in unnecessarily cost increases. Diamond that contains too much manganese will cause computer read-rite heads to depolarize pole tips in a lapping operation rendering them useless.

Other synthetic diamond particles that are based on surface attraction forces from upstream processing can easily adhere to one another. This adherence can form clusters that can be connected by a network of interconnected pores or surface ions. These clusters are known as agglomerates. Agglomerates will create processing problems if they are used in suspensions because they distort the distribution of particles and create unwanted artifacts as scratches on polished surfaces or voids in solid pieces. A medical prosthesis as a hip ball needs to be a solid piece. Tiny voids created by these agglomerates can cause stress

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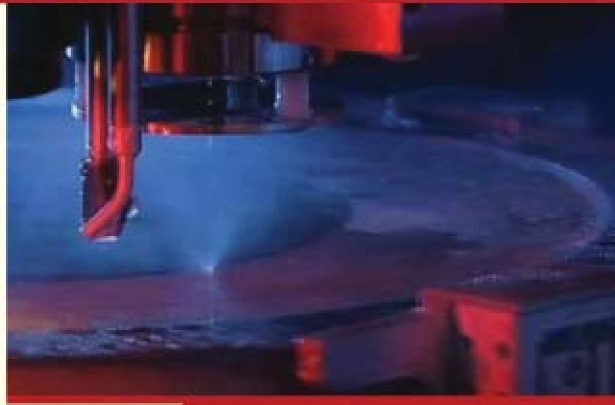
New Process for Cutting of CBN and PCD Inserts: Water-Jet-Guided Laser

DELPHINE PERROTTET, ROY HOUSH and
BERNOLD RICHERZHAGEN • Synova SA



Introduction

PCD and CBN are commonly used as inserts in machine tools for high-speed cutting, milling or turning machines because of their exceptional tool life. However, because of their hardness, it is difficult to cut the different shapes of the inserts (typically triangles, rectangles or lozenges) from larger discs or plates. During this manufacturing step, several important requirements should be taken into consideration. The edges have to be smooth and parallel, and the cutting kerfs narrow in order to lose as little material as possible. Burrs should be avoided, as well as material changes due to heating. Speed is also an important criterion as cutting hard materials can be time-consuming, especially for important thicknesses (typically between 1 and 4 mm).

Cutting hard materials with diamond saws is problematic because of the important tool wear and the slowness of the process. Thin gaps cannot be obtained, resulting in costly material loss. Moreover, only straight cuts can be made. EDM cannot be used if the material is not electrically conductive and it is a very slow process. Conventional lasers are a possible solution, but the process generates particles and thermal damages that have to be removed with post-processing steps. Furthermore, conventionally focused lasers produce conical kerfs. If conventional lasers can be used for CBN drilling in some cases, cutting is still very problematic. A new alternative is the use of the water-jet-guided laser technology, a revolutionary technology combining a low-pressure, hair-thin water jet with a laser beam.

Water-jet-guided laser

The water-jet-guided laser technology, also called Laser MicroJet, is innovative in the sense that the laser beam is not directly focused on the work piece, as for conventional laser systems, but guided inside a water jet by means of total internal reflection at the water/air interface, similarly to conventional glass fibers (see Figure 1).

The use of a low-pressure, hair-thin water jet makes this technology completely different from other laser-based technologies. Indeed, besides its primary guiding function, the water jet has two major effects that are paramount for precision cutting. First, the water jet removes most of the particles generated by laser ablation. As a thin water film is generated on the work-piece surface during cutting, contamination is negligible. In second place, the heataffected zone is extremely thin, since the continuous water jet cools the work piece between the laser pulses.

Another important effect of the water-jet guiding is to generate parallel kerfs, since the cylindrical water jet guides the laser energy down to the bottom of the cut; the conical effect present in conventional laser cutting is avoided. In addition, very narrow kerf widths are possible due to the use of small nozzles.

For this particular application, a common jet diameter is 36 _m. Powerful lasers near their maximum intensity (high peak powers) are preferably used because of the temperature stability of these materials and the thickness of the inserts; it is also important to use pulsed lasers with high pulse repetition rates, as the edge quality is improved.

Polycrystalline Diamond

Polycrystalline Diamond (PCD) is a synthetic diamond, exceptionally resistant to wear, used in a wide range of machining operations. Usually, the PCD diamond layer is bonded to a tungsten carbide (WC) substrate, which provides strength and a brazable base for bonding to other metals.

During insert production, both layers need to be completely cut. The water-jet-guided laser performs this operation with excellent quality and reasonable cutting speed, considering the thickness of the pieces that have to be cut:

- Thin samples (1.1 mm WC and 0.5 mm PCD): cutting speed 10.9 mm/min
- Thick samples (2.7 mm WC and 0.7 mm PCD): cutting speed 8 mm/min

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Summary

Cutting of hard materials, for example cubic boron nitride (CBN) and polycrystalline diamond (PCD), is a high-requirement process; among the existing techniques, very few are efficient. The new water-jet-guided laser technology has been improved over the years to complete such a delicate operation. The reached cutting speeds are higher than for most processes. No post-processing steps are required to clean the inserts after cutting, as the level of contamination directly after cutting is very low and since heat influence is negligible. Thanks to the particularities of the Laser MicroJet, the cut is parallel and very regular. This innovative technology, able to cut any material, providing that its absorption coefficient at the laser's wavelength is sufficient, is today the most promising tool for hard-material cutting.

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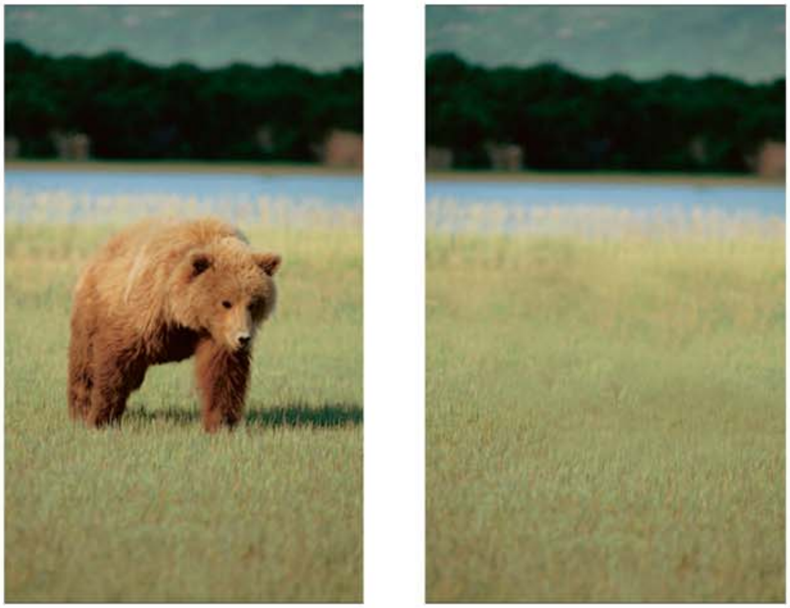
- ◆ Establishes Industry Standards
- ◆ Interacts With Global Associations And Organizations
- ◆ Creates And Distributes Market Studies & Data
- ◆ Organizes And Presents Technical Seminars
- ◆ Serves As A Government Liaison For Industry Guidelines And Regulations
- ◆ Participates As Member Of World Diamond Council
- ◆ Provides Safety / Regulatory Reports And Advisement
- ◆ Resource For General Information And Consultation

OTHER MEMBER SERVICES

- ◆ PUBLISHES QUARTERLY MAGAZINE
- ◆ HOLDS ANNUAL CONVENTIONS
- ◆ HOSTS IDA WEBSITE WITH MEMBER FOCUS AND DIRECTION
- ◆ PROVIDES SPECIFIC ASSISTANCE ON INDIVIDUAL MEMBER ISSUES
- ◆ CREATES AND DISTRIBUTES PUBLICATIONS ON PRODUCTS AND APPLICATIONS
- ◆ ACTS AS A COLLECTIVE VOICE FOR INDUTRY CONCERNS



Here today…

But what about tomorrow? While hundreds of millions of Americans are enjoying the wonders of our national parks each year, the future of the very things they're coming to see is at risk.

For example, although the Mexican black bear population has been slowly recovering at Big Bend National Park, their ongoing survival is threatened.

Americans for National Parks is a coalition working to preserve these national treasures, and all the priceless experiences they provide. Find out how you can help at **www.americansfornationalparks.org.**

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A public service message of this publication.

CHECKLIST *of things to do…*

FINER POINTS

- ☐ Renew my subscription to Finer Points magazine.
- ☐ Reserve my ad space in the next Finer Points issue.
- ☐ Submit article for consideration in future issue of Finer Points.
- ☐ Send Finer Points my business news, new products, new hires, promotions, industry news and other press release items.
- ☐ Send in my membership application to the IDA.
- ☐ Refer a company to IDA for consideration as a member.
- ☐ Visit the IDA Website at: www.superabrasives.org and submit a question or comment.
- ☐ Mark my calendar to attend Intertech 2008, May 19-21, 2008 in Orlando, Florida.

INTERTECH 2008

An International Technical Conference on Diamond, Cubic Boron Nitride and their applications.

www.intertechconference.com

ORLANDO FLORIDA USA

CORRECTIONS TO LISTINGS IN SUPERABRASIVE RESOURCE DIRECTORY

Under Manufacturer/Supplier Land Superabrasives Company listing should read in bold with ad page listed as follows:

Land Superabrasives Company
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New York, NY 10036-5803
Fax: 212-354-4622
Email: info@landssuperabrasives.com
Website: www.landssuperabrasives.com
See Ad on Page 7

Under Distributors Crown Industrial Supply has a incorrect e-mail address and website, they should be listed as:

Crown Industrial Supply Of Steiner
1250 W Touhy
Elk Grove Village, IL 60631 USA
Phone: 847-871-5200
Fax: 847-871-5201
Email: wdelnea@stnr.com
Website: www.steinerelectric.com

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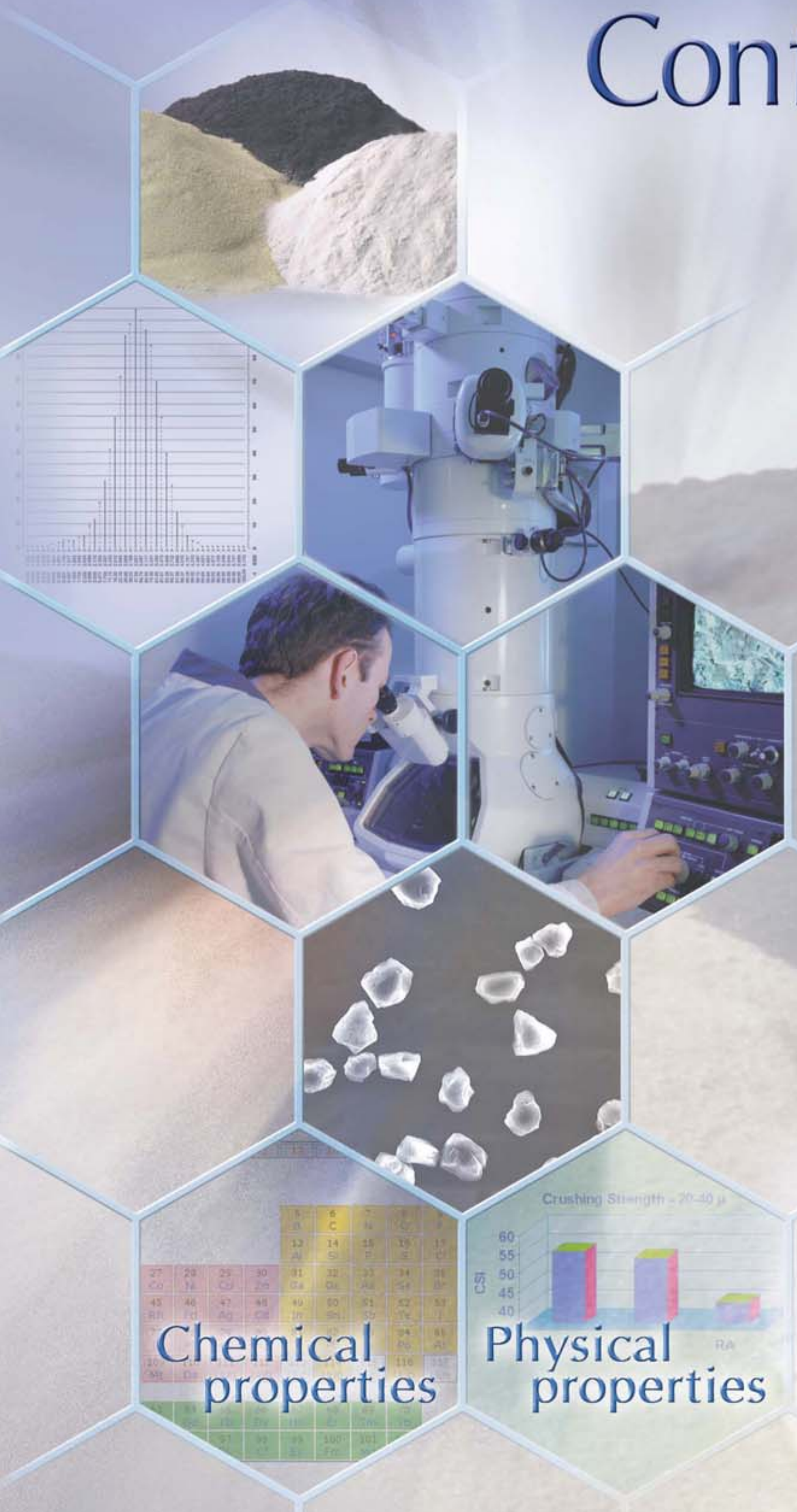

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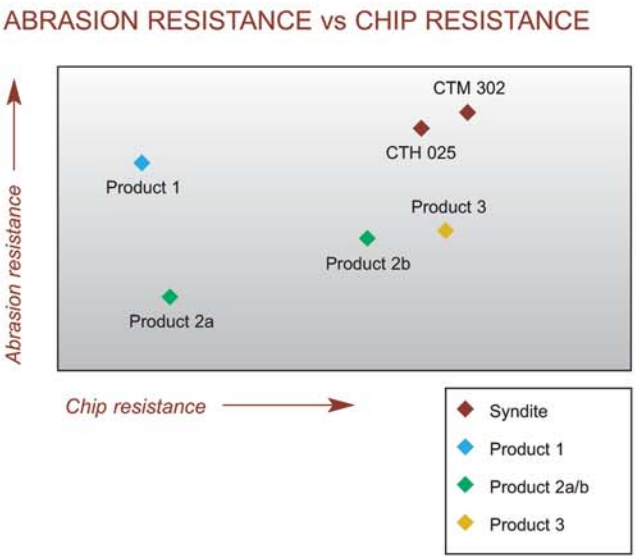

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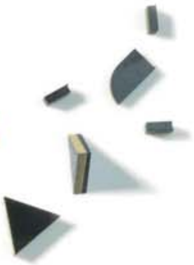

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